UTAH STATE IMPLEMENTATION PLAN
SECTION IX PART B
CONTROL MEASURES FOR AREA AND POINT SOURCES
SULFUR DIOXIDE

IX.B.1 HISTORY OF NonattAINMENT AREAS DESIGNATION AND SIP SUBMITTALS

     In the Federal Register of September 11, 1978, there were three areas in Utah that were designated as nonattainment for sulfur dioxide (SO_2). These three areas include:

               1.   Salt Lake County
               2.   Tooele County
               3.   Cedar City

     The designation of Cedar City as a nonattainment area for SO_2, made by the State, was based on ambient air quality data collected at the State's monitoring station on the campus of Southern Utah State College (now Southern Utah State University).

     The designation of Salt Lake and Tooele Counties was made by the U.S Environmental Protection Agency (EPA), based on data collected at the State's ambient air monitoring stations in Magna and Tooele. The old reverberatory furnace system at the Kennecott Copper Corporation's Utah Smelter was still in operation at that time. On March 13, 1981, EPA revised the nonattainment designation for Tooele County to exclude all areas except those above 5600 feet. The main concern of the SIP for Salt Lake and Tooele Counties as proposed by the State and EPA's proposed approval was control of emissions from Kennecott.

     On August 16, 1981 the State submitted a State Implementation Plan (SIP) for the control of SO_2 in Salt Lake County, Tooele County, and Cedar City to the EPA. The primary control measure in the SIP for Salt Lake and Tooele Counties was the construction of a new smelter at Kennecott Copper Corporation to replace the old reverberatory furnace system. The only control measure in the SIP for Cedar City was enforcement of the existing limitation for sulfur content in fuel oil used at Southern Utah State College. In December of 1983, Cedar City was redesignated an attainment area for SO_2.

     On March 23, 1984, in 49 FR 10946-10950, EPA proposed approval of this implementation plan for control of SO_2 from the Kennecott smelter contingent upon submittal of an approvable good engineering practice stack height demonstration. Prior to final approval, EPA requested that the State make several additional commitments as a part of the SIP.

     In February 1982, EPA promulgated "stack height" regulations (47 FR 5864). In October 1983, portions of those regulations were overturned by the U.S. Court of Appeals for the D.C. circuit. The outcome of this decision affected the Utah SIP because the modeling to demonstrate attainment with the National Ambient Air Quality Standards (NAAQS) for SO_2 considered emissions from Kennecott Copper Corporation's tall stack. If it was determined that the stack height did not meet "good engineering practices", the results of the model might be affected. In order to resolve this issue, the Utah Air Conservation Committee (now the Air Quality Board) committed to the following:

     1.   When EPA promulgated new regulations applicable to stack heights as mandated by the courts, the Committee would require Kennecott to prepare a demonstration of the adequacy of the smelter main stack to assure attainment of ambient standards when stack height was taken into account. Upon approval by the Committee of the required demonstration,

the Committee would then submit the demonstration to EPA.

2. If the demonstration required by the Committee showed that attainment could not be achieved based on any new stack height requirements promulgated by EPA as a result of the court decision, the Committee was to revise the SIP consistent with the new height requirements.

In 1986, after questions concerning the stack height regulations were resolved, the State submitted Section 17 (since renumbered to Section 16) of the Utah Implementation Plan, Demonstration of GEP Stack Height, to EPA. This SIP demonstrated that the height of the Kennecott tall stack met the criteria for "good engineering practices." EPA was required to approve or disapprove this SIP within one year of submittal, and to also issue final approval or disapproval of the SO_2 SIP, based on the stack height determination for Kennecott's tall stack.

On November 15, 1990, Congress amended the Clean Air Act. Section 107(d)(1)(C)(i) of the Amended Act states that any area designated as nonattainment on November 15, 1990 is automatically redesignated as nonattainment. Because the SO_2 SIP had not yet been approved, Salt Lake and Tooele Counties were automatically redesignated as nonattainment areas, even though no violations of the standard had been recorded since 1980. Section 191(b) of the amended Act requires any state with a nonattainment area lacking a fully-approved implementation plan for SO_2 as of November 15, 1990 to start over again, and resubmit a new SIP by May 15, 1992. Because of the amendments to the Clean Air Act, the State was required to resubmit both the GEP Stack Height SIP, and the SO_2 SIP to the EPA.

On December 18, 1991, the State submitted a new GEP Stack Height SIP to the EPA. Once again, this SIP demonstrated that the height of Kennecott Copper Corporation's tall stack met "good engineering practices." Based on this demonstration, the modeling performed in 1981 SIP to demonstrate attainment of the NAAQS standard for SO_2 in Salt Lake and Tooele Counties is still a valid demonstration.

IX.B.2 SULFUR DIOXIDE CONCENTRATIONS

        Sulfur dioxide concentrations have been measured at two stations in the Salt Lake County nonattainment area, at one station in the Tooele County nonattainment area, and at three stations in the Cedar City nonattainment area. A summary of the data for Salt Lake City and Cedar City are shown in Figure IX.B.1.

Sulfur Dioxide (ppm)

	Salt Lake		Magna		Cedar City	
	2nd High 24-Hr Avg.	# Greater than NAAQS	2nd High 24-Hr Avg.	# Greater than NAAQS	2nd High 24-Hr Avg.	# Greater than NAAQS
1977					.02	0
1978					.04	0
1979	.05	0	.15	49	.04	0
1980	.11	0	.17	35	.02	0
1981				0		
1982	.04	0	.09	0		
1983	.03	0	.06	0		
1984	.08	0	.07	0		
1985	.07	0	.08	0		
1986	.09	0	.00	0		
1987	.02	0	.01	0		
1988	.04	0	.07	0		
1989	.07	0	.07	0		
1990	.03	0	.07	0		

	Salt Lake		Magna	
	2nd High 3-Hr Avg.	# Greater than NAAQS	2nd High 3-Hr Avg.	#Greater than NAAQS
1982	.10	0	.22	0
1983	.08	0	.22	0
1984	.11	0	.17	0
1985	.12	0	.14	0
1986	.13	0	.02	0
1987	.05	0	.20	0
1988	.08	0	.19	0
1989	.13	0	.16	0
1990	.07	0	.15	0

NAAQS   Primary =   0.03 ppm, annual arithmetic mean
                         0.14 ppm, 24-hour average concentration
             Secondary = 0.5 ppm, 3-hour average concentration

Note: 24-hour and 3-hour NAAQS may be exceeded once each year

FIGURE IX.B.1

IX.B.3 CONTROL STRATEGIES

IX.B.3.a. Cedar City.

        The State operated an ambient monitoring station which measured concentrations of SO_2, and particulates in Cedar City, Utah from April 1975 to 1980.

        Violations of the primary and secondary Ambient Air Quality Standards for SO_2 were observed in 1975 and only the Primary NAAQS was violated in 1976

and 1977. The 1977 maximum 24-hour average concentration was 0.21 ppm and the second high 24-hour running average was 0.18 ppm. A review of the emission inventory indicated that there are no major sources of SO_2 in Cedar City.

An investigation was conducted to determine the source of SO_2 which resulted in violations of the NAAQS. The State's monitoring station was located on the campus of the College of Southern Utah (now Southern Utah State University) and was southwest of and near the college heating plant which is fired with fuel oil. A review of the monitoring data showed that violations of the NAAQS occurred during the winter season when easterly winds were observed. Two special-purpose monitoring units were installed upwind from the original monitoring site to determine how widespread the high concentrations might be and to help pin-point the source. Although SO_2 was detected by the new units, the concentrations were well below the NAAQS. The data collected at the two stations are shown in Figure IX.B.2. As a result, efforts to locate the source were directed to the vicinity of the original monitoring unit.

It was believed that the station had been fumigated by the plume from the college heating plant. A sample of the fuel oil used in the plant was analyzed; the sulfur content (8.1% by weight) was substantially higher than that allowed by the Utah Air Conservation Rules (1.5% by weight).

The college was informed of the violation of the sulfur content of fuels requirement. They immediately acquired a supply of fuel oil which met the requirements. That change is the control strategy and resulted in attainment of the NAAQS for SO_2 in Cedar City. The original monitoring station was left in operation until 1978 to determine the attainment status. One of the special-purpose monitoring stations was also left in operation until 1980.

Maintenance of the NAAQS for SO_2 in Cedar City will be achieved through enforcement of the sulfur content of fuels regulations. (See [~~Subsection R307-1-4.2, Utah Air Conservation Rules~~]R307-203-1).

IX.B.3.b Salt Lake and Tooele Counties.

A careful review of the emissions inventory and diffusion modeling which was coordinated by the State indicated that the emissions from one point source, Kennecott Copper Corporation, resulted in violations of the NAAQS for SO_2 which were observed in both counties.

Ambient measurements taken by the Department of Health in Salt Lake County indicated that the NAAQS were violated only at the site in Magna, Utah. Based on this information, the Magna monitoring site was used as the control point for development of the control plan. No violations of the NAAQS have been observed at any of the monitoring stations since 1980.

To attain and maintain the ambient air quality standards in Salt Lake and Tooele Counties, it was and continues to be necessary to control SO_2 emissions from the Kennecott operation. In 1981, the Utah Air Conservation Rules were revised to include emission limitations and control requirements for the following Kennecott operations:

1. Smelter Main Stack
2. Fugitive Emissions
3. Power Plant
4. Molybdenite Heat Treaters
5. Refinery

As part of the approval process for the 1981 submittal by the State, the EPA performed a modeling analysis. Figure IX.B.3 shows the distribution and expected concentrations of SO_2 as determined by diffusion modeling, using the

CDMQC model. The highest predicted concentration of SO_2 was at Lake Point, which is on the property of Kennecott Copper Corporation. Figure IX.B.4 shows the location of Lake Point as well as the 5600-foot level contour of the Oquirrh Mountains and the Kennecott Utah Copper property boundary. In 1979, Kennecott established a monitor at Lake Point to measure SO_2 concentrations.

On August 15, 1991 the State promulgated a State Implementation Plan for the control of PM_{10} in Salt Lake County. Because SO_2 is a precursor of PM_{10}, the SIP relied heavily on reductions of SO_2 emissions to control PM_{10} in the Salt Lake/Davis County nonattainment areas. As part of the PM_{10} SIP, Kennecott Copper Corporation agreed to install double-contact acid plant technology as well as other control measures that would result in SO_2 emission reductions from the facility. As required to protect the 3-hour NAAQS for SO_2, a 3-hour emission limit has been included in Section IX, Part H, Emission Limits. The discussion in IX.B.3.c below details the development of that limit.

By comparing the ratio of Kennecott Copper Corporation's 1981 SO_2 emissions limitations and the 1991 PM_{10} SIP emissions limitations, and using the modeling/monitoring ratio established in the 1981 SO_2 SIP, the State is able to demonstrate that the SO_2 NAAQS will not be exceeded in Salt Lake County or Tooele County as detailed in IX.B.3.d below.

IX.B.3.c. Development of the 3-hour Tall Stack Emission Limit.

One of the principle requirements of the 1992 SO_2 SIP revision is the establishment of a 3-hr emission limit for the tall stack at the Kennecott smelter. This limit will reflect the new levels of control agreed upon as part of the PM_{10} SIP which resulted in new emission limits for both 24-hour and annual averaging periods. This new level of control will be achievable through the application of available double contact acid plant technology.

The total emissions from the tall stack are composed of two distinct sources: 1) fugitive smelter emissions captured by the secondary ducting, and 2) tail-gas emissions from the acid plant(s).

Kennecott Utah Copper (KUC), in a meeting held January 10, 1992, proposed to the State a 3-hour emission limit of 6,900 lbs/hr. This limit contains a 4,500 lb/hr contribution from the ducted fugitive emissions, which is the same estimated contribution used to establish the 24-hr limit of 5,700 lbs/hr which was used in developing the PM_{10} SIP. This is based on an assumption that fluctuations in these fugitive emissions should be negligible when comparing a 3-hr period with a 24-hr period. The remainder of the 6,900 lb/hr limit would then be 2,400 lbs/hr from the acid plant(s). The contribution from the acid plant(s) would correlate to a tailgas SO_2 concentration of 1,300 ppm. In a subsequent letter, dated 1/14/92, KUC presented its' rationale for the selection of this tailgas concentration. That letter is contained in the technical support document, and is summarized below.

KUC has based their proposal of 1,300 ppm on certain sections of an EPA document titled 'Review of New Source Performance Standards for Primary Copper Smelters' (1984). They begin with Table I-2 (from appendix I of that document, and herein referred to as Fig. IX.B.5) which summarizes SO_2 concentration data collected (in 1973) every 15 minutes from the tailgas of a double contact acid plant at the ASARCO copper smelter in El Paso, Texas. The table compares the probability of exceeding various concentration levels (from 150 to 750 ppm) with the effect of different averaging times used to calculate the measured concentration (from 15 minutes to 10 hrs). As the averaging time increases, and as the reference concentration level increases, the probability of exceeding that reference level decreases significantly. For a 3-hour averaging period, the probability of exceeding a tailgas concentration of 750 ppm is reported by the study as 0.5%.

From that point, KUC looked at the highest concentration reported for the representative averaging period (also reported in Table I-2), which for the 3-hour period was 1,238 ppm, and averaged the two. This procedure yielded a value of: (750 ppm + 1,238 ppm)/2 = 994 ppm.

The next step was to account for the effects of normal catalyst deterioration with a "safety" factor of 30%. Thus: 994 ppm X 1.3 = 1,292 ppm, and this number was finally rounded up to the 1,300 ppm which KUC proposed.

During the review of the KUC proposal, the State determined the origin of the 30% deterioration level. Table G-3 of the same EPA document summarizes tailgas SO_2 concentrations from a different study - one which compared the tailgas concentration of Kennecott's No.6 acid plant with the tailgas concentration of their No.7 acid plant. The data for this study was collected over a three day period in 1972, and during that time the average concentration of the No.7 plant exceeded that of the No.6 plant by roughly 30%. This difference in performance was attributed entirely to the deterioration of the catalyst in the No.7 plant, even though the two plants are of different age, design and manufacture. Both plants, however, routinely clean their catalysts over a 12-month cycle, and while the No.7 plant was in its twelfth and final month, the No.6 plant was in only the second month of its cycle. The assumption was that because catalyst deterioration (primarily a function of pressure drop across the catalyst bed) should occur exponentially, and should become a factor only during the latter stages of the cleaning cycle, this was the only difference in the performance of the two acid plants. Thus, said the KUC study, it would be reasonable to apply a 30% deterioration factor when establishing a regulatory emission factor for a new double contact sulfuric acid plant.

There is no question as to whether or not the catalyst in an acid plant will deteriorate and thereby diminish the performance of the plant. Therefore, it is the responsibility of the State to verify that a proposed 30% is a reasonable performance reduction estimate. When the ASARCO study was further analyzed, it was pointed out that the data collection took place during what was considered to be the second and third quarters of the plant's 24-month cleaning cycle. Thus, making the same "exponential" assumption, there would have been little if any adverse effect due to catalyst deterioration for that double contact acid plant. Recognizing that such effects should be accounted for when establishing an emission limit, the study team posed the question of how much deterioration could reasonably be expected, and their "discussions with the designers of the ASARCO acid plant indicated that up to a 10% increase in emissions was expected before renewal of the catalyst."

Furthermore, in an effort to apply the results of their findings to other acid plants, the study team made the following statement in their conclusion: "To account for situations of increased emissions due to higher inlet (SO_2) concentrations of up to 9%, the results of Table I-2 require prorating upward a maximum of 200 ppm".

Therefore, based on the above analysis, it was the decision of the State to adopt the conclusions of the ASARCO study for the purposes of establishing a 3-hour emission limit for the tailgas SO_2 concentration of KUC's new acid plant. As a result of this position, the State: 1) accepted KUC's starting point of 750 ppm as corresponding to a 99.5% confidence level (even though Table I-2 showed the same degree of certainty associated with 700 ppm); 2) added 200 ppm to that figure to account for possible differences in or fluctuations of the inlet SO_2 concentration; and 3) allowed a 10% margin of "safety" to account for the effects of catalyst deterioration, thereby arriving at a 3-hour SO_2 limit as follows:

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(750 ppm + 200 ppm) X 1.1  =  1,045 ppm
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which would correlate to a lb/hr figure as:

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1,045 ppm X (2,400 lbs/hr / 1,300 ppm)  =  1,929 lbs/hr
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which could be rounded to 1,950 lbs/hr, and, added to the 4,500 lbs/hr
contribution from the ducted fugitive emissions, to arrive at a 3-hour average
emission limit of 6,450 lbs/hr.

IX.B.3.d Analysis of Control Strategy.

The SO_2 emission limits as required for the control of PM_{10} and SO_2 for
the annual, 24- and 3-hour averages for the main smelter stack are, therefore,
respectively, 3,240, 5,700 and 6,450 lb/hr. The annual and 24-hour limits
represented RACT for the development of the PM_{10} SIP. The 3-hour limit
represents the amount of control sufficient for the attainment of the 3-hour
SO_2 standard in the nonattainment area. Low level emissions (low stack and
fugitive emissions) are not considered in evaluating the impacts on the
elevated terrain (i.e., Lake Point) for three reasons: 1) The exact quantities
of fugitive emissions are unknown; 2) Low level emissions have not caused any
violations at low level monitors since 1980, and their impacts on the high
level terrain would appear even lower or probably insignificant; and 3)
Ignoring low level emissions and attributing impacts solely to the main stack
will be more conservative for the control of main stack emissions.

(1) Evaluation of 24-hour Impacts on Lake Point
Using Previous Modeling Results

EPA previously used the Valley model to estimate impacts at different
distances and elevations. The model evaluated annual impacts using an annual
emission rate of 2,293 g/sec or 18,200 lb/hr. The model then converted the
annual impacts to 24-hour averages. The modeling results are contained in the
technical support document.

Both Lake Point and a site [designated as "Point A"] which is the point
closest to the main stack on elevated terrain outside Kennecott property, are
about 4.5 km distance from the main stack, and are shown on a map contained in
the technical support document. The previous EPA modeling results did not
include impacts at 4.5 km distance. Use of a linear interpolation gives a 24-
hour impact of 570 $\digamma$g/m^3 at Lake Point.

Using the new annual emission rate of 3,240 lb/hr, the 24-hour impact is
then estimated as

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(3,240 lb/hr)x(570 ug/m3)/(18,200 lb/hr) = 102 ug/m3 = 0.039 ppm.
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To be more conservative in estimating the 24-hour impact, the new 24-
hour emission rate of 5,700 lb/hr is used as an annual emission rate. The 24-
hour impact is evaluated as

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(5,700 lb/hr)x(570 ug/m3)/(18,200 lb/hr) = 179 ug/m3 = 0.068 ppm,
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which is lower than the 24-hour standard of 0.14 ppm.

To be even more conservative in estimating the 24-hour impact, the new
3-hour emission rate of 6,450 lb/hr is used as an annual emission rate. The
24-hour impact is then evaluated as

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(6,450 lb/hr)x(570 ug/m3)/(18,200 lb/hr) = 202 ug/m3 = 0.076 ppm,
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which is still lower than the 24-hour standard of 0.14 ppm.

(2) Evaluation of 24-hour Impacts on Lake Point
Using Previous Monitoring Data

Another method to estimate the impact of the main stack emissions using the new emission limits is to use previous monitoring data at Lake Point and stack emission rates. The monitoring and emission data for the worst case episode of 0.33 ppm of 24-hour average on 11/30/79 is contained in the technical support document.

The 24-hour average emission rate at the hour of the maximum running 24-hour average concentration of 0.33 ppm was 38,228 lb/hr. Because the plume from the stack took an unknown time to reach Lake Point, the maximum concentration observed at the monitor was caused by emissions prior to the hour when the measurements were taken. Since the emission data showed that the emission rates prior to the highest concentrations were higher than 38,228 lb/hr, using an emission rate of 38,228 lb/hr results in a more conservative approach. The 24-hour impact of the new 24-hour emission rate is estimated as

$$(5,700 \text{ lb/hr}) \times (0.33 \text{ ppm})/(38,228 \text{ lb/hr}) = 0.049 \text{ ppm},$$

which is also lower than the 24-hour standard.

(3) Evaluation of 3-hour Impacts on Lake Point

The monitoring data at Lake Point and emission data can be utilized to evaluate the 3-hour impact from the new emission rates. From the monitoring data for running half-hour contained in the Technical Support Document, the maximum 3-hour average concentration during the episode period on 11/30/79 was conservatively estimated as 1.0 ppm.

The exact 3-hour average emission rate causing the 1.0 ppm impact is unknown. Since the emission data in the technical support document indicates that the emission rate of 24-hour average was lower than that of the 3-hour average, using the 24-hour emission rate of 38,228 lb/hr as the 3-hour emission rate will give more conservative results. The 3-hour impact from the new 3-hour emission rate is evaluated as

$$(6,450 \text{ lb/hr}) \times (1.0 \text{ ppm})/(38,228 \text{ lb/hr}) = 0.17 \text{ ppm},$$

which is also below the 3-hour standard.

(4) Summary

The estimate results for maximum impacts from the new stack emissions on Lake Point are summarized in Table IX.B.1.

Estimated impacts on Lake Point

Average	Emission rate (lb/hr)		NAAQS (ppm)	Impact (ppm)	Evaluation method
24-hr	5,700	0.14	0.068		Modeling
			0.049		Monitoring
3-hr	6,450	0.5	0.27		Modeling
			0.17		Monitoring

IX.B.3.e Protection of the 3-hour SO_2 Standard.

The EPA has required the State to ensure that the 3-hour SO_2 NAAQS will be protected, as well as the 24-hour and annual NAAQS.

The emission limitation for the tall stack at Kennecott Copper Corporation was established using a 3-hour average and a multi-point formula in the 1981 SO_2 SIP. The 1991 PM_{10} SIP revised this limitation to establish a 24-hour standard for SO_2 emissions and eliminated the multi-point limitations allowed in the 1981 SIP. The EPA accepted the new SO_2 limitation as a control strategy for the PM_{10} SIP, but required the State to develop a 3-hour emission limit for the tall stack as part of the new SO_2 SIP. Section IX, Part H, Emission Limits, has been revised to include a 3-hour emission limitation for the smelter tall stack as detailed in IX.B.3.d above.

The EPA also required the State to revise the sulfur content of fuels requirement in it's regulations. The existing rules specified a limit for the sulfur content of fuels, but did not specify an averaging time or specific ASTM methods. Subsection R307-1-4.2 of the Utah Air Conservation Rules have been revised to include a 24-hour averaging period for the sulfur content of coal, fuel oil, and fuel mixtures, and to specify the ASTM methods to be used to demonstrate compliance with the limitations and reporting requirements. It is the state's position that, because there is no high-sulfur natural gas in Utah, there is no need for a rule which specifies testing methods for deter- mining sulfur content of natural gas or fuel mixtures containing natural gas.

Subsection R307-1-4.6 was revised to include a 3-hour averaging time for Sulfur Burning Production Sulfuric Acid Plants.

IX.B.4 EMISSION LIMITATIONS.

See Section IX, Part H of the Utah Implementation Plan for the new emissions limitations for Kennecott Copper Corporation.

See Subsection R307-1-4.2 of the Utah Air Conservation Rules for limitations on the sulfur content of fuels.

IX.B.5 ADEQUACY DEMONSTRATION.

Monitoring performed in Cedar City, Magna, and Salt Lake City has shown no violations of the NAAQS for SO_2 from 1981 to 1992. The control measures proposed in this SIP have already been shown through actual measurements over the recent past 10-year period to be adequate to maintain the standards.

SULFUR DIOXIDE (ppm)

	ANNUAL MEAN	2ND HIGH 24-HR. AVG.	# GREATER THAN NAT'L PRIMARY 24-HR.	# GREATER THAN NAT'L SECONDARY 24-HR.
Cedar City (1st East)				
1977	.009	.02	0	0
1978	.00*	.04	0	0
1979	.00*	.04	0	0
1980	.00*	.02	0	0
Cedar City (High School)				
1977	.005	.01	0	0

NAAQS - Primary - 0.03 ppm annual arithmetic mean, 0.14 ppm 24-hour average concentration; Secondary - 0.5 ppm 3-hour average concentration

NOTE: 24-hour and 3-hour NAAQS may be exceeded once each year.

* Annual mean is less than .005 ppm SO_2

Figure IX.B.2

Figure IX.B.3

Figure IX.B.4

The Effect of Reference Concentration Level and Averaging Time on the Percentage of Excursions

Averaging Time	Number of Readings	150	200	250	300	350	400	450	500	550	600	650	700	750	Maximum Concentra-tion ppm
15 min	14,612	20.00	15.00	10.00	7.50	5.00	4.00	3.00	2.30	1.60	1.35	1.15	1.05	1.05	2,920
1 hr	3,628	20.00	15.00	10.00	7.10	4.10	3.15	2.65	2.10	1.75	1.40	1.00	0.90	0.80	1,982
2 hr	3,702	20.00	15.00	10.00	5.00	3.00	2.50	2.00	1.75	1.50	1.25	1.00	0.90	0.70	1,261
3 hr	3,758	20.00	15.00	10.00	5.00	2.20	2.00	1.60	1.25	0.85	0.80	0.55	0.50	0.50	1,238
4 hr	3,803	20.00	8.15	6.10	3.06	2.20	1.40	1.05	0.80	0.75	0.50	0.45	0.30	0.25	935
5 hr	3,841	20.00	10.00	5.00	2.75	1.75	1.25	1.00	0.75	0.55	0.40	0.30	0.25	0.15	935
6 hr	3,876	20.00	10.00	5.00	2.45	1.75	1.20	0.90	0.45	0.35	0.30	0.15	0.05	0.05	752
7 hr	3,901	20.00	10.00	5.00	2.15	1.40	1.00	0.55	0.30	0.20	0.10	0.05	0.00	0.00	662
8 hr	3,935	15.00	10.00	5.00	2.15	1.40	0.80	0.50	0.25	0.10	0.05	0.00	0.00	0.00	662
10 hr	3,988	15.00	10.00	5.00	2.05	1.20	0.55	0.25	0.10	0.05	0.00	0.00	0.00	0.00	576

Figure IX.B.5